

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey of Calhoun County, Iowa

By

W. E. THARP

United States Department of Agriculture, in Charge
and

T. H. BENTON and W. J. LEIGHTY

Iowa Agricultural Experiment Station



Bureau of Chemistry and Soils

In cooperation with the Iowa Agricultural Experiment Station

BUREAU OF CHEMISTRY AND SOILS

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A. G. McCALL, *Chief, Soil Investigations*

SOIL SURVEY

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P. E. BROWN, *in Charge Soil Survey*

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By W. E. THARP, United States Department of Agriculture, in Charge, and T. H. BENTON and W. J. LEIGHTY, Iowa Agricultural Experiment Station

COUNTY SURVEYED

Calhoun County is in the northwestern part of Iowa. (Fig. 1.) Rockwell City, the county seat, is 75 miles northwest of Des Moines and about 100 miles northeast of Omaha, Nebr. The county is approximately square in outline and includes an area of 568 square miles, or 363,520 acres.

Nearly all the county occupies an uneven plain having an elevation of about 1,100 feet above sea level. The elevation decreases noticeably from northeast to southwest.

The predominant surface features include broad uneven ridges and low knolls, most of which do not rise more than 20 or 30 feet above the intervening depressions.

The depressions range from mere sags, a few acres in extent, to wide ill-defined flats with numerous extensions that either grade on to the surrounding low slopes or eventually connect with some of the waterways. The southeastern townships include much rather flat land consisting mostly of wide depressions with comparatively low divides between them. In the southwestern townships there is a somewhat larger proportion of rolling and somewhat hilly land, nearly all of which is along the streams. The valley of Raccoon River, which is from 1 to 2 miles wide, cuts off about 12 square miles of the southwest corner of the county. The actual flood plain, through which the river runs in a sinuous course, is in few places more than one-fourth mile wide, but the bench lands extend back two or three times as far to the steep upland slopes which rise to an elevation of 40 or 50 feet. There is also a second level of benches, only a little lower than the adjoining uplands, but their total area in the county is less than 3 square miles.

Natural drainage systems are inadequately developed, but they have been so extended and improved artificially that even the lowest lands are soon relieved of the heaviest rainfall. Formerly the surface run-off and the seepage from the hillsides collected in local depressions from which they escaped by evaporation, were absorbed by the subsoil, or eventually found their way into the sloughs and creeks. In dry seasons most of the small ponds disappeared and hay could be made on the marshy sloughs, and animals were pastured on them. The upper half or two-thirds of the smaller creeks are now artificially enlarged ditches from 5 to 15 feet deep, and their angular

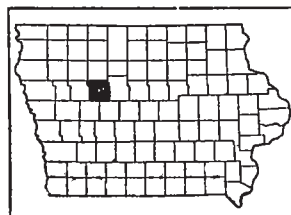


FIGURE 1.—Sketch map showing location of Calhoun County, Iowa

courses across the county are marked by cottonwood trees that thrive well along the banks.

The originally high average level of the ground water in most of the larger depressions has undergone a reduction of several feet. Many small depressions and the margins of the larger ones remote from either tile drains or open ditches have now only short periods of saturation compared with the marshy conditions that formerly prevailed practically all summer. Drainage is greatly facilitated by the granular structure of the subsoil materials. To what extent the actual reserves of subsoil water may have been reduced since the precultural period can not be stated. The wells range from 50 to 150 feet in depth, as shallow wells no longer suffice for farm use.

The many different soils in the Racoon Valley are all assured effective drainage, the steep slopes effect drainage of the bordering uplands, and the underlying gravels facilitate drainage of the level bench lands. The ground-water level of the first bottoms seems to keep in close adjustment with the prevailing shallow waters in the wide river channel.

The first settlement in Calhoun County was at Lake City in 1854, and the county was organized in 1855. The population in 1880 was 5,595, all of which was classed as rural. In 1930, the inhabitants numbered 17,605. Rockwell City is the largest town, with a population of 2,108. Lake City ranks next, with 2,012 inhabitants.

Between 1880 and 1890 many people from Illinois, who had had previous experience in land drainage, immigrated to Calhoun County. The present combined system of natural and artificial drainage reaches every farm and leaves little to be desired with respect to convenience in field operations.

The county is crossed by five railway lines, and an electric line from Rockwell City to Des Moines is used for freight. State Highways Nos. 5, 17, 20, and 151 serve the county, and about 600 miles of the 1,100 miles within the county are surfaced with gravel.

The use of trucks for delivery of grain and livestock to markets and the collection of dairy products is maintained throughout the entire year. Practically all farms have telephones and are reached by rural delivery of mails. In most rural districts, schools are maintained for grade pupils and advanced students are transported to the village schools.

CLIMATE

The climate of Calhoun County is characterized by wide extremes in temperature. The winters are long and usually severe, but they are broken by an occasional more moderate spell. During the short summer there are brief periods of extreme heat. The average daily wind movement is high during the spring and sometimes continues into the summer as very warm winds from the southwest.

The mean annual precipitation of 33.38 inches is well distributed throughout the year, most of the precipitation in winter occurring in the form of snow. Heavy spring rains occasionally delay planting, and short periods of drought have been recorded in July and August, but are rare.

Field operations usually begin early in April and cease by the middle of November. The average date of the last killing frost is May

5 and of the earliest is October 7, giving an average frost-free season of 155 days. The latest frost recorded was on May 27 and the earliest on September 11.

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation at Rockwell City which is centrally situated in the county.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Rockwell City, Iowa

[Elevation, 1,134 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1908)	Snow, average depth
	^{°F.}	^{°F.}	^{°F.}	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
December.....	22.4	60	-32	0.98	1.81	0.90	6.7
January.....	18.4	58	-35	1.00	.75	.60	9.1
February.....	19.6	60	-32	1.33	.22	2.45	9.0
Winter.....	20.1	60	-35	3.31	2.28	3.95	24.8
March.....	34.6	86	-14	1.61	1.35	2.48	6.9
April.....	47.4	96	10	3.05	3.77	2.50	1.6
May.....	59.2	96	17	4.93	.78	6.70	.2
Spring.....	47.1	96	-14	9.59	5.90	11.68	8.7
June.....	69.0	101	36	4.73	2.02	10.65	.0
July.....	73.8	106	42	3.79	.11	8.10	.0
August.....	71.7	103	36	3.62	1.75	7.45	.0
Summer.....	71.5	106	36	12.14	3.88	26.20	.0
September.....	63.4	98	20	4.05	1.37	1.10	.0
October.....	51.7	91	7	2.89	3.80	5.20	.4
November.....	36.4	76	-16	1.70	.11	1.85	1.9
Fall.....	50.5	98	-16	8.34	5.28	8.15	2.3
Year.....	47.3	106	-35	33.38	17.34	49.98	35.8

AGRICULTURE

For many years agricultural development in Calhoun County was slow and was confined entirely to the well-drained lands. In 1880, according to the United States census returns, there were 862 farms averaging 121 acres in size, of which about 60 per cent was classed as improved land. By 1930 the number of farms had increased to 2,174, the average size to 164.7 acres, and the percentage of improved land to more than 90 per cent.

The general trend in crop production since 1879 is indicated in Table 2, which is compiled from the United States census reports.

TABLE 2.—*Acreage and production of principal crops in Calhoun County, Iowa, in stated years*

Crop	1879		1889		1899	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn.....	27,019	981,698	77,348	2,975,258	116,026	4,340,660
Oats.....	5,540	168,416	34,937	1,400,063	68,934	2,851,690
Wheat.....	8,619	106,399	1,311	17,037	18,300	288,880
Rye.....	304	4,689	285	3,835	911	12,060
Barley.....	399	7,555	535	13,929	124	1,270
Flax.....		16,529	7,279	73,137	1,238	11,470
Potatoes.....		39,317	1,535	150,170	1,879	162,534
		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>
Hay.....	14,013	26,661	68,550	83,397	52,377	69,761
Silage crops.....						
Coarse forage.....					749	2,017

Crop	1909		1919		1929	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn.....	107,137	3,895,657	136,271	6,560,106	145,112	6,257,288
Oats.....	83,272	2,095,289	119,608	4,819,081	117,406	5,154,106
Wheat.....	667	11,047	3,149	40,567	333	6,919
Rye.....	10	150	328	5,926	367	9,332
Barley.....	1,816	29,132	316	8,325	2,356	79,093
Flax.....	107	707	5	17		
Potatoes.....	1,145	87,608	590	27,119	672	74,845
		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>
Hay.....	38,738	56,539	20,972	28,081	12,519	22,273
Silage crops.....			1,050	9,413		
Coarse forage.....	272	576	2,308	5,602		

The steady increase in the acreage of both corn and oats is the result of a combination of favorable agencies still existent in this general region. Although numerous other important crops may be grown in Calhoun County, none is quite so well adapted to meet all the present requirements with respect to crop rotations, economy of labor, transportation, and markets. The agricultural habits of the people are inherited, as most of the first settlers came from corn-growing States to the east, and the present farmers show a strong preference for this type of farming.¹

The corn acreage is constantly held up to or even beyond the rotational ratio best calculated to conserve soil fertility. This is especially noticeable on Clarion loam, but the Webster soils, notwithstanding their capacity for enduring severe cropping to corn, need more frequent changes to grasses and legumes.

Oats remain in favor largely because no other small grain gives quite such reliable returns. The farmers state that the average profits are low. The decline in wheat growing seems attributable to a number of causes. Warm weather just preceding harvest seriously affects yields, and damage by the chinch bug and Hessian fly sometimes occurs. Rye and barley have never been in general favor. Flax was formerly useful as a first crop on prairie sod but was never very extensively grown. Buckwheat, sorghum, cane, millet, and soybeans are little more than catch crops, and are regularly grown by very few farmers. The present acreage of alfalfa (4,969 acres) is widely scattered over the county in patches of a few acres each.²

¹ HOLMES, C. L. TYPES OF FARMING IN IOWA. Iowa Agr. Expt. Sta. Bul. 256, p. [116]—166, illus. 1929.

² Acreage and production figures are taken from the United States census reports unless otherwise stated.

According to the Iowa Yearbook of Agriculture for 1928, mixed stands of timothy and clover were grown on 3,573 acres, and each crop grown alone occupied 362 acres. The total acreage of sweet-clover for all purposes is about 3,730 acres.

Clovers of all kinds receive most attention from farmers who habitually keep a large number of cattle and other livestock. Many farms, especially those operated by tenants, are not well fenced or otherwise arranged for profitable use of grass and forage crops. Much of the oat straw is used in winter care of livestock, and practically none is sold. Hay is often purchased by operators of big grain farms.

In recent years hired labor has been reduced to the minimum. Only a few farmers regularly employ help. The compensation is about \$50 a month, with board and laundry furnished. The daily wage during harvest is around \$3.

A representative set of farm buildings includes a 2-story square house, painted white; a large red barn; a corncrib with driveway in the middle, overhead storage bins for oats, and elevator for unloading grain; hog and poultry houses; garage; and either windmill or gas engine for pumping water.

The field implements include 2-row cultivators, gang plows, disks, smoothing harrows, and latest types of binders for harvesting grain. Corn pickers are rapidly coming into general use. Tractors and 5 to 8 horse teams furnish the motive power. According to the Iowa Yearbook of Agriculture for 1928, there are 646 tractors, 2,050 automobiles, 311 trucks, and 978 radio sets on farms, and the assessors' returns for 1928 show 9,460 work horses and mules.

The crop rotation most commonly used by the farmers of Calhoun County consists chiefly of alternations of corn and oats. Since the annual acreage of corn exceeds that of oats, the ratio being about 7 to 5, the difference is offset by a limited acreage of corn following corn, tame grasses, clovers, and some miscellaneous crops. Spring plowing for corn is seldom as satisfactory as fall plowing, and on well-managed farms spring plowing is reduced to the lowest possible acreage. As a rule the fall-plowed ground of all types is rendered so crumbly, or mellow, by the winter's weathering that going over it once with a disk, followed by a smoothing harrow, fits it for planting. After spring plowing, the land is usually more cloddy and requires much extra tillage. About three cultivations are all that the corn receives, as oat harvest crowds very closely on the corn plowing. Oat harvest in 1929 began about July 10, and the first cutting of alfalfa was also ready about this date. The principal varieties of oats grown are Iowa 103, and Green Russian. By growing these two varieties the ripening period is spread over two or three weeks. All grain is threshed from the shock, and as soon as the big oat fields are cleared, fall plowing for the next corn crop is begun. Hay making, the second cutting of alfalfa, and the care of the few miscellaneous crops are minor field operations compared with preparation for the next corn crop and caring for the present one. Field work usually closes before Thanksgiving Day.

In 1930, tenants operated 58.1 per cent of the total acreage of farm land, owners 41.1 per cent, and managers 0.8 per cent. Rental is usually one-half of the corn and two-fifths of the oats. Cash pay-

ment for grassland ranges from \$7 to \$9 an acre. Many large farms are operated under joint management by which the tenant furnishes labor, implements, and horses and an equal division is made of the gross sales of products. Farms so operated usually include more livestock than is commonly sold from the farms under a cash rent or grain lease.

Calhoun County is in the "cash-grain section" of Iowa.³ About three-fifths of the corn, during a normal year, is sold direct from the farms, and a somewhat higher proportion of the oats is marketed. In the majority of instances all the landlord's share of the grain is sold.

About 95 per cent of the corn crop is husked and cribbed, less than 1 per cent fills the silos, and about 5,600 acres are hogged down. Most of the corn delivered to the elevators is shelled on the farm. The cobs are an important item of fuel.

On a few farms in each township the feeding of cattle is a regular part of the farm operations, but on the great majority of owner-operated farms and nearly all those managed by tenants, the sale of hogs constitutes the largest single item of income from livestock. The sale of milk and cream is also an important source of income on most farms. Cream-buying stations are maintained in every town by the large creamery companies and packing houses. Poultry production has assumed great importance, but specialization in this line and also in dairying has not developed to a great extent. The most important special crop is pop corn. About 600 acres were devoted to this crop, chiefly in the southwest townships, in 1929. Several hundred acres of sweet corn are grown near Rockwell City for the canning plant in that town.

Prices of farm land vary according to location, conditions of improvements, and the character of the soil included in the individual farm. Farms consisting largely of Webster soils are considered the most valuable. According to the county recorder's book, 5,963 acres of land in Calhoun County changed ownership between May 1, 1928, and May 1, 1929.

SOILS AND CROPS⁴

Corn and oats are the principal crops, their combined acreage equaling almost two-thirds of the total area of the county. This acreage is rather uniformly distributed, and there are few farms on which the care of these two products does not constitute the greater part of the season's work. According to the Iowa Yearbook of Agriculture for 1928, corn, which is the major crop in all respects, occupies almost 150,000 acres; oats, 110,000; and in recent years 7,000 acres has sufficed for all the wheat, rye, and barley grown. About 50,000 acres are used for pasturage and about 10,000 are annually allotted to tame grasses and legumes for hay.

According to an actual survey of the crop distribution in 1929, on 8 representative sections of 640 acres each, the crop acreages were as

³ See footnote 1, p. 4.

⁴ Calhoun County adjoins five Iowa counties that have previously been surveyed. In places the soils as mapped in Calhoun County do not have the same names as those mapped in adjoining counties. For example, the Fargo soils mapped in Webster County in 1914 are now known as the Webster soils. By a change in definition the Carrington soils mapped in Greene and Carroll Counties are combined with the Clarion soils of Calhoun County. The designations of a few minor soil types have also been changed.

follows: Corn, from 43 to 51 per cent of the total area of the section; oats, from 31 to 42 per cent; tame grasses and clover, from 11 to 18 per cent; and alfalfa, from less than 0.5 to 3 per cent. Surveys of a number of other sections gave similar results.

This crop distribution was influenced in some measure by the soil type, which is, in general, a very subordinate factor, the chief exception being the soil of creek bottoms and steep hillsides, which is used as permanent pasture.

The individual areas of the three dominant soil types are so intimately associated that differential management is not practical except in a very general way. Moreover, all these soils, with some unimportant exceptions, are loams and silty clay loams and so well supplied with organic matter that there are no very wide differences in their moisture properties and tillage requirements. This is also true of the content of nitrogen, phosphorus, and potash as indicated by chemical analyses.⁵ The more nearly level soils, which are almost black and heavy in texture, are somewhat richer in these elements than soils of coarser texture and less intensely dark color.

Soil acidity is not a serious problem, and in all soils of the county the strong lime content in the subsoil becomes apparent a few feet below the surface. These favorable soil characteristics, as well as other factors influencing their productivity, favor extensive rather than intensive methods of farming. This has resulted in the present predominance of corn and oats and the reduction to a very subordinate place of various other crops to which the soils themselves are just as well adapted as to these major products.

The greater part of the naturally well-drained soils is included in Clarion loam, and Webster silty clay loam embraces nearly all those areas that were formerly wet so large a part of each season as to be untillable. Webster loam represents intermediate conditions between the two more extensive soils with respect to local elevations, effectiveness of drainage, and depth to which the organic matter extends. In this survey each of these three major soil types has been given some latitude with regard to minor variations in surface slope, organic content, degree of acidity, and depth to free lime. These variations within the typical soil areas should be kept in mind in the following descriptions, and in the interpretation of the soil map.

A comparison of the map with the lay of the land shows that in this region of sags and swells, low ridges, and wide depressions a close relationship exists between the soils and local surface configuration. In nearly all low areas like that occupied by the fairground at Rockwell City, Webster silty clay loam is mapped. In this instance a little peaty soil occurs in the lowest part of the central depression. The soil of the adjoining knoll on which the high school stands is Clarion loam, but a better development of this soil occurs on the gentle slopes bordering the numerous small valleys crossed by State Highway No. 20. Any upland field as flat as the courthouse square has a soil much like Webster silty clay loam, whereas on gentle slopes like those to the east and south of the square, or those in the residential section of the town to the west, the undisturbed soil in most places is Webster loam.

⁵ STEVENSON, W. H., BROWN, P. E., with the assistance of ORRSEN, C. L., FORMAN, L. W., and MELDRUM, H. R. GREENE COUNTY SOILS. Iowa Agr. Expt. Sta., Soil Survey Rpt. 44:21. 1927.

In the following pages of this report, the soils of Calhoun County are described in detail, and their agricultural importance is discussed. The accompanying soil map shows their distribution in the county, and Table 3 gives their acreage and proportionate extent.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in Calhoun County, Iowa*

Type of soil	Acre	Per cent	Type of soil	Acre	Per cent
Clarion loam.....	126,336	34.7	Lamoure silty clay loam.....	6,336	1.7
Clarion loam, steep phase.....	4,672	1.3	Waukesha loam.....	576	.2
Clarion sandy loam.....	512	.1	Fargo clay.....	64	.1
Pierce loam.....	896	.2	Wabash loam.....	3,840	1.1
Dickinson fine sandy loam.....	320	.1	Wabash silty clay loam.....	708	.2
Sioux loam.....	4,480	1.2	Wabash silt loam.....	512	.1
Sioux sandy loam.....	192	.1	Cass fine sandy loam.....	896	.2
O'Neill loam.....	704	.2	Muck.....	4,096	1.1
Webster silty clay loam.....	142,080	39.1	Muck, shallow phase.....	384	.1
Webster loam.....	65,280	18.0			
Benolt loam.....	576	.2	Total.....	363,520	-----

WELL-DRAINED SOILS

Of the group of soils having good natural drainage, Clarion loam is by far the most important type. Other members of this group are the Pierce, Dickinson, Sioux, and O'Neill soils. All are less rich in organic matter than the formerly poorly drained soils, and this difference has doubtless been accentuated by the somewhat longer period of cultivation to which the well-drained soils have been subjected. Part of these changes on the more rolling phases is caused by mild forms of erosion, but everywhere the increased oxidation of organic matter brought about by tillage and the removal of important elements of fertility by crops are the greater and more general causes concerned in the soil changes. The combined effect of these agencies is becoming apparent in the gradually increasing necessity of crop rotations and the use of legumes and manure. Almost all reference to these practices in the discussion of Clarion loam apply equally well to the Pierce, Sioux, and Dickinson soils.

Clarion loam.—This extensive soil occupies the broad gently rounded divides, prominent knolls, and gentle slopes bordering the creek valleys. On some of the steeper inclines and tops of sharp knolls, the plow may occasionally bring up some of the yellowish-brown subsoil, but elsewhere the dark loam is from 15 to 20 inches thick. This entire upper layer is well supplied with organic matter, the soil of the immediate surface layer has a good crumb structure, and the friability of the surface part is increased by the moderately high proportion of sand. Below plow depth, there may be slight compaction, but nowhere does the soil material approach an impervious condition. All the soil in the dark subsoil layer is granular in structure, which facilitates drainage and aeration. This desirable condition extends into the yellowish-brown subsoil layer which is more or less coarse crumbly in structure. In most places it is clay loam containing more sand and pebbles than the dark layer above. At a depth ranging from 30 to 40 inches below the surface, pale-yellow silty material, which is friable and contains an abundance of free lime, occurs. Deep-rooting plants have no difficulty in penetrating to the lime-bearing zone.

The surface soil is more or less acid, so also is the subsoil to a depth ranging from 20 to 30 inches. The acidity in the surface soil is in few places so pronounced as to directly affect plants. Good stands of red clover are sometimes obtained without an application of lime. Acidity may be a contributing factor in clover failures, and liming always increases the yields and proves profitable.

Since most of this soil has been under tillage for 40 or more years, the original supply of new humus, or decaying vegetable residue, has largely disappeared, and the remaining organic matter is the old inert form that does not directly contribute so much to the plant food supply as the new or fresh humus. Therefore, all phases of this soil respond promptly to manure and are temporarily improved by changes to grass. Farmers also state that sweetclover makes a marked improvement in the following yields of corn. No commercial fertilizers are in use, but lime has been applied in numerous places, chiefly in order to insure better stands of clover.

The average yields of corn, as reported by farmers, are about 40 bushels an acre. The yields on the flatter areas, which include some Webster loam, are higher than on the slopes. The soil on the slopes is more susceptible to drought, but if well manured, or if the organic supply has been otherwise maintained, the difference in crop yields in normal seasons is not very marked. The slightly earlier planting possible on this soil and the somewhat earlier maturity of crops thereon, are compensating factors for its somewhat lower productivity compared with the Webster soils. Yields of corn ranging from 60 to 75 bushels an acre are not unusual under favorable conditions.

Yields of oats range from 25 to 60 bushels an acre. Oat yields are doubtless more directly affected by seasonal conditions than those of corn, but farmers state that land having had frequent changes to grass, or which has received applications of manure preceding corn in the rotation, give better average yields of oats than similar areas of the soil not so treated.

The land is satisfactorily used for a great variety of minor crops. Since the majority of the farm homes are located on land of this kind, it affords sites for many orchards and gardens, and numerous kinds of native and introduced shrubs find it a congenial soil.

Clarion loam, steep phase.—This steep soil as mapped includes the steep blufflike slopes facing the valleys, and it also includes the rougher lands extending up short ravines and tributaries of the main streams. The dark-brown surface layer is thin or may be entirely lacking in spots where the pale-yellow subsoil shows so plainly when the land is used for tilled crops. Most of the phase is included in permanent pastures. Although not capable of retaining moisture so well as the smoother areas of Clarion loam, grasses and clover do well in seasons of average rainfall. The yellow subsoil layer is more or less friable to a depth of several feet and this condition, combined with an abundance of lime, especially favors the production of clover. On the steep slopes bordering the Sioux and Dickinson soils, the soil may be very sandy in places, and seepy spots occur along the upper slopes.

Clarion sandy loam.—On some of the more prominent knolls and small ridges of the uplands south of Raccoon Valley, Clarion loam contains more gravel and sand than is usually present in this soil.

In places the sand and gravel content increases and the surface soil ranges from dark-gray gritty loam to brown sandy loam. Such areas have been separated on the soil map as Clarion sandy loam. The variable depth to yellow-brown clay loam does not commonly exceed 25 or 30 inches. Here and there gravelly spots occur, and such areas are a little more droughty than the heavier soil.

This soil responds very well to manure and all crop changes that increase the humus supply. All the land is in cultivation, and crop returns in normal seasons are similar to those on the rolling areas of Clarion loam.

Pierce loam.—The small areas of Pierce loam are on the crests of rather prominent mounds and narrow ridges on which there are more or less gravel and stones. At a variable depth, but commonly less than 12 or 15 inches, the coarse-textured surface loam changes to brown gravelly loam which may form a layer a foot or more thick. With increase of depth the material changes to lighter-colored sand and gravel with many rounded stones. This mixed coarse material extends to a depth of many feet and is very rich in lime. A short distance down the slope, this soil gives place to some phase of Clarion loam. No sharp line of demarcation occurs, and as a rule the outer margins of the areas indicated as Pierce loam are very much like the Clarion soils. Here and there small areas of Pierce loam occur on comparatively smooth upland, and the underlying gravel lies at a depth ranging from 20 to 30 inches from the surface.

The agricultural value of this variable soil is determined chiefly by the thickness of the loam layer. All phases of the soil are subject to drought, but fairly good yields of corn and oats are often obtained, and clovers will grow on all but the most stony areas. Excavations for gravel have destroyed the agricultural value of many small areas in the northern townships. The larger acreages in the south-central townships have not suffered so much in this respect and are mostly high, uneven divides, where the soil is much in need of crops of clover to restore the humus lost by erosion and frequent cropping to corn.

Dickinson fine sandy loam.—This soil is a deep sandy loam or fine sandy loam occurring along the crest of the high hills south of Raccoon River. At the top of the slopes the soil is moderately dark grayish-brown friable sandy loam, changing with depth to yellow silty sand, which is somewhat coherent when moist but loose when dry. At a depth ranging from 50 to 60 inches either clay or a gravelly layer may occur. A short distance back from the crest of the slope the surface soil in most places becomes darker and finer textured, and the depth to the yellow-brown subsoil clay decreases. Less than one-fourth mile back from the top of the hill most of this soil merges with Clarion loam.

In comparison with Clarion loam the yields of corn and oats are usually lower, and bluegrass pastures are less dependable. In seasons of moderately high and well-distributed rainfall the crops mentioned give much better returns. This soil is not used to any extent for early truck or melons, but it affords locations that are favorable for these crops and for soybeans.

Sioux loam.—Sioux loam is the dominant soil on the high second bottoms of Raccoon Valley. The basic materials of these bench

lands are thick bedded sands and gravels with a comparatively thin cover of loam. The immediate surface layer ranges from very dark grayish-brown silt loam to dark grayish-brown sandy loam, in which there may be much gravel. The lighter-colored phases predominate, and a distinctly mineral-brown color indicates a lower percentage of organic matter compared with the Clarion soils. Reddish-brown coarser-textured loam or sandy loam occurs a little below plow depth. With increase in depth this material gradually changes to sand or to mixed sand and gravel, all of which are light-colored and rich in lime. This change occurs in a somewhat irregular manner, as indicated by borings and exposures in gravel pits, but commonly at less than 5 feet. The surface soil is acid in most places, and the intermediate layers are not sufficiently alkaline to respond to hydrochloric acid.

The more sandy areas of this soil commonly occur on the low swells and other local elevations, and the heavier and darker-colored variations are limited to the flat areas and slight depressions. In the latter situations crops resist prolonged dry weather somewhat better than on the higher ground. This is particularly true of corn, but all field crops give most satisfactory yields in seasons of well-distributed rainfall. Excessive precipitation during any period of the growing season does not affect crops or unduly delay tillage as on the heavier soils.

Practically all this soil is in regular use for tilled crops. All phases respond well to manure and to clover or other soil-improvement crops. Management in this respect, as well as tillage and seasonal influences, greatly affects the yields of corn, more so than on the dark-colored and heavier soils. Yields of corn, also oats, ranging from 25 to 50 bushels an acre, are reported by the farmers of the county. This soil was formerly used rather extensively for wheat, and good crops were obtained. This was probably because the soil warmed up slightly earlier in the spring and had a lower moisture content than the surrounding soils. The low moisture content is not so favorable for clovers, but after a stand is made the crop does well. Liming seems necessary for success with alfalfa, probably on account of the acidity of the surface soils.

The upper soil layer is distinctly acid and in places there is a lack of lime in the upper part of the brown gravelly subsoil. The naturally low organic-matter content has been materially reduced by long cropping to corn and oats. All except the low spots, which are essentially a dark soil, are in need of manure or clovers turned under to renew the humus supply.

Sioux sandy loam.—Sioux sandy loam is mapped on a few ridges lying slightly higher than, and surrounded by, Sioux loam. The surface soil consists of rather light sandy loam to a depth of several feet. All the areas are in tillage, but field crops are more susceptible to damage from dry weather than on Sioux loam. The surface soil is acid. Sioux sandy loam is very similar to O'Neill sandy loam as mapped in adjoining counties. It occupies a little higher position than Sioux loam.

O'Neill loam.—O'Neill loam occurs on the highest bench lands along Raccoon River. The surface features are very similar to those of Sioux loam, but the depth to lime-bearing gravel is in most

places greater, and the surface soil may show a somewhat higher degree of acidity. In other respects the two soils are almost identical.

SOILS HAVING SLOW NATURAL DRAINAGE

A group of dark-colored soils includes most of the soils having such slow natural drainage that they were formerly unsafe for cultivated crops. Their present artificially improved drainage gives them high agricultural value, and they have proved especially important in the economic development of this region. Included in this group are the Webster, Wabash, and several other soil types. All are rich in organic matter and in most places are well supplied with lime. The inherently heavy character of these soils is very favorably modified by their crumbly, or granular, condition due chiefly to the presence of organic matter and lime. All these dark soils have these desirable physical characteristics which are especially noticeable in the Webster soils. The surface soil under normal field conditions assumes a rather soft crumbly, or mellow, condition which may be favorably influenced by the small but perceptible proportion of fine sand commonly present. All the land yields easily to tillage, if this is not attempted when the ground is wet, and the crumbly or mellow condition is well retained throughout the growing season.

In some of the lowest situations there is so much organic matter that the surface layer may be slightly mucky, but this condition is disappearing under continued use of the soil for tilled crops. There are also rather numerous small patches where the subsoil is black clay which is especially waxy when wet. This phase is called "gumbo" by the farmers, but it is not extensively developed. It commonly occurs in low situations where the surface loam is less than 8 inches thick. Here and there a bowlder may be present on the Webster soils, but there is very little stony material.

The surface soils in some places are slightly acid, but in most places they are neutral or give a slightly alkaline reaction. There is usually no free lime in the subsoil to a depth of several feet, except in the so-called alkali spots. Here an abundance of lime may occur between depths of 20 and 40 inches, rendering the surface zone light colored and very friable. The alkali spots occur along the margins of low-lying areas and are not only limited in extent but are disappearing where the land is properly drained, manured, and fertilized.

Webster silty clay loam.—Webster silty clay loam embodies practically all the important characteristics described for this group of soils. It has such an extensive distribution that there are few farms outside the Racoon Valley which do not include some areas of this soil, and many farms consist almost entirely of this valuable land. It is the premier corn soil of the county. The average yields over a long period may be placed at about 50 bushels an acre, but returns of 75 or 80 bushels are not uncommon. The areas covered by this estimate include the alkali spots and many small inadequately-drained areas, also fields that have had few changes to crops other than oats for many years. The availability of the plant food and the exceptional ability of these soils to endure both dry and wet weather, as well as hard cropping, insure these favorable returns.

Yields are usually higher on fall-plowed land than on spring-plowed land, as the spring-plowed land lacks the full effect of freezing and thawing, so highly beneficial to this clayey soil. Although corn may not mature quite so early as on the Clarion and Sioux soils, the liability to frost damage seems but little higher. The quality of both white and yellow varieties of corn is excellent. The average yields in 1929, as reported by farmers, are around 50 bushels an acre, which is near the average over a period of years. Little attention has been given the selection of varieties best adapted to this soil.

Webster silty clay loam is now so little used for wheat or rye that definite statements as to yields of these crops are not obtainable. A few fields of barley were grown in 1929. This soil is especially well adapted to all the clovers which thrive most vigorously in all low spots where a high lime content is indicated by the abundance of snail shells. Sweetclover grows so luxuriantly that it is sometimes difficult to eradicate when the ground is planted to corn. No difficulty is experienced in obtaining a stand of alfalfa, and many patches are grown on this soil. The soil meets the requirements of truck crops requiring high fertility and a dependable moisture supply. Potatoes, tomatoes, and cabbage are very successfully grown. This is essentially the same kind of soil so satisfactorily used for sugar beets in other localities.

Few of the farm improvements are located on this type of soil, but the high estimation in which the soil is held enhances the value of all farms on which it forms much of the land.

Webster loam.—Owing to its slightly higher topographic position, Webster loam has better natural drainage than Webster silty clay loam. Most of the loam is tillable without the installation of tile drains, but practically all would be benefited by them. The shallow sags and small, rather flat spots, prominent in recently plowed fields, owing to the darker color of the surface soil, are in need of tile drainage almost as much as the larger areas of Webster silty clay loam. Like the silty clay loam, the loam has a crumbly or granular structure which facilitates tillage and allows efficient internal drainage and deep aeration. In general, the moisture properties and ability to endure dry weather are very similar to those of Webster silty clay loam.

The surface soil is soft, crumbly, silty loam responding well to tillage if moist but inclined to pack or become cloddy if worked or trampled while wet. The black granular clay subsoil seldom occurs at a depth of less than 12 or 15 inches, and in this important respect, this soil differs from Webster silty clay loam. In many places free lime occurs a little below the dull yellowish-brown and drab zone which lies at a depth of about 30 inches but in some places is much deeper.

The surface soil is, in places, slightly acid, but in most places the subsoil is neutral or alkaline below a depth ranging from 10 to 15 inches. This soil includes no alkali spots, and in very few places is the surface soil so limy as to contain snail shells as do some areas of the silty clay loam. With these exceptions the adaptation to corn, oats, and other field crops does not differ greatly from that of Webster silty clay loam. As mapped the areas include many slight local elevations and short slopes on which Clarion loam occurs.

Benoit loam.—Benoit loam occurs on low benches and local elevations along the small streams. Most of the areas are only a few feet higher than the adjoining bottom land, but they escape ordinary overflows. The surface soil resembles Webster loam except on the sharper slopes and highest points, where it is usually brown or yellowish-brown gritty loam containing some gravel and stones. Most of the land is nearly, if not quite, as resistant to drought as Webster loam. The lighter-colored phases may be slightly acid, and the darker ones are neutral or alkaline. The depth to gravel is variable, ranging within small areas from 10 to 40 inches. The gravel is highly calcareous and includes many limestone fragments and enough calcium carbonate to feebly cement small masses of the coarse material. In many places the gravelly layer is only a foot or two thick and is underlain by calcareous clay. Some parts of the areas near Cedar Creek, in Williams Township, are of this character.

Benoit loam, as a whole, has about the same crop adaptations as Clarion loam of the adjoining slopes. The included dark spots of deeper and more silty loam compensate in large measure for reduced yields on the gravelly areas when dry weather occurs at a critical stage in crop growth. The pasturage value is less than that of the adjoining bottom lands.

Lamoure silty clay loam.—Lamoure silty clay loam represents the alluvial soils along the small creeks, which seem to be somewhat richer in lime than the otherwise similar soils on the larger streams. According to simple field tests, the former are more commonly neutral or slightly alkaline than the latter. In most places the soil in these little valleys resembles Webster silty clay loam in texture, structure, and general character of material to a depth of several feet. The originally poor drainage has been improved by the enlargement of ditches and straightening of the channels, but all the land is subject to overflow and is therefore used chiefly for pasturage. Bluegrass and white clover thrive especially well and have almost entirely displaced the native grasses.

The exceptionally high waters of the overflows in June, 1930, left much sediment in the grassy growth on each side of the streams, although the greater part lodged in the channels or was carried to the trunk streams. Where examined, this deposit was found to be strongly alkaline. This suggests the cause of the high lime content of the soil and the desirability of retaining as much of this material as possible by the maintenance of a good grass cover.

Waukesha loam.—Typical Waukesha loam has a dark-colored surface soil, from 10 to 15 inches thick, underlain by brown heavier loam or clay loam. At a depth of 3 feet or slightly less the material becomes more friable and lighter in texture. This soil is less acid than Sioux loam but is not commonly so well supplied with lime as the soils of the Webster series. As a rule the depth to lime-bearing material is several feet, though in a few exceptional spots the surface soil is rich in lime. This soil is typically a well-drained soil occurring on the higher terraces, but as mapped in Calhoun County it includes a number of small areas of other soils, some of which are poorly drained. These soils occur at the foot of slopes and extend down to the poorly drained parts of the second bottom or in the sags and depressions on the terraces. The surface soils in such areas are commonly blacker and heavier in texture than those

of typical Waukesha loam, and the subsoils are slightly mottled or gray. These spots require artificial drainage.

Waukesha loam is all in cultivation and is managed in much the same way as the Webster soils.

Fargo clay.—To a depth of 6 or 8 inches Fargo clay is nearly black clay or silty clay loam, which is sticky and cohesive when wet but on becoming partly dry is coarse and crumbly. The granular structure and dark color are very apparent in well-tilled fields. Below plow depth the soil material is dark-drab or bluish-drab clay, in which there is less tendency to separate into angular aggregates than in the surface layer, although the soil cracks deeply on severe loss of moisture. In most places there is no marked change in the character of the soil material to a depth of several feet except that the color becomes lighter with depth.

Fargo clay occurs on flat areas in the Raccoon River bottoms, where it is associated with Wabash silty clay loam. Owing to the higher clay content it is not quite so easily tilled as the Wabash soil, and this difference would be more apparent were it not that the Fargo material is richer in organic matter and lime. To these constituents is due in large measure the friable character of the surface layer when moist, but if the soil is either wet or exceptionally dry, satisfactory tillage is almost impossible. For this reason much of the land is not regularly used for corn, although high yields are often obtained. Bluegrass, timothy, and the clovers thrive well and form the varied growth observed in the permanent pastures.

Wabash loam.—Wabash loam includes the soil of some of the first bottoms along the small creeks. These lands are nearly flat, but the depth of the creek channel commonly holds the ground water level several feet below the surface soil, and the granular structure of the subsoil allows good internal drainage. Overflows occur occasionally but in most places are seldom of more than a few hours duration, although water may remain in the local depressions for a longer period. Such conditions limit the safe use of most of these narrow valleys to pasturage. Bluegrass and white clover thrive exceptionally well, and their vigorous growth is less affected by dry weather than on the upland soils. The higher proportion of silt and sand in this soil tends to prevent compaction and the consequent loss of moisture that occurs on more clayey soils much trampled by livestock. The ground water level, governed by stages of the near-by channel, may also be a source of capillary water and tend to uniformity in moisture content of the upper soil layers.

Wabash silty clay loam.—A few small areas in the creek bottoms, in which the surface soil is black crumbly, or granular, clay and the subsoil is of similar character to a depth ranging from 30 to 40 inches, are mapped as Wabash silty clay loam. As a rule, the surface is flat and lies a little lower than the adjoining bottom lands. When wet, the soil is highly plastic or becomes waxy if cultivated when wet or trampled by livestock. This renders it difficult to manage even in situations otherwise favorable to tillage. All the land is used for pasture.

Small areas lie along Hardin Creek and the lower course of Prairie Creek. A similar dark stiff clayey soil occurs along Raccoon River. The areas are lower than the adjoining Wabash silt loam and are sometimes inundated by backwater from the river. This, as

well as the storm waters from the hills, slowly disappears from these local basins. All this land affords excellent pasturage, but it is not satisfactorily tillable.

Wabash silt loam.—Wabash silt loam occurs in the first bottoms of Raccoon River. Much of the land lies just a little above normal overflow, but it is not entirely immune from the higher waters. The dark surface soils range from silty clay to coarse-textured loam, but in nearly all areas they contain much silt and therefore are very friable and in few places seem as heavy as Wabash loam along the small streams. The dark color commonly extends to a depth of 2 or 3 feet, in some places as deep as 5 feet. Below a depth of 5 feet more yellow tints prevail down into the sandy substratum. Local drainage is good, and except for the susceptibility to overflow, all this soil is well adapted to tillage. Most of it is utilized for corn, and in numerous places many successive crops have been grown with little use of manure or clovers. The yields of corn commonly exceed 40 bushels an acre and often reach 50 or 60 bushels. Various minor crops, including potatoes and garden vegetables, are grown. Grasses and clovers of all kinds do well, and the small areas not safely tillable afford excellent pasturage.

Cass fine sandy loam.—Cass fine sandy loam occupies the bottom lands immediately bordering the channel of Raccoon River, which are in general a few feet lower than the general level of the Wabash soils, especially the areas on the inner side of the numerous horseshoe bends. They include the sand bars in process of formation and the more silty depositions at somewhat higher levels, which are commonly sandy loam or fine sandy loam with a high proportion of silt. As a rule, the deeper subsoil is a lighter sand, but in many places this is below the reach of a 40-inch soil auger. The dark silty material prevails to a depth of several feet.

All these areas are subject to rather frequent overflows, but the inundations are usually of short duration, except in low spots where backwater may remain a much longer time. Here a stiff dark-colored clay of variable thickness overlies the sandy substratum.

The original forest cover on these areas included soft maple, ash, and elm, with willow and cottonwood along the river banks. On the somewhat higher ground, oaks and walnuts were more numerous, together with some hickory and other hardwoods. Nearly all the larger trees have been removed, and most of the land is now in blue-grass pasture with scattered trees or only occasional patches of woods.

Muck.—Muck, or the so-called "peat soils" of Calhoun County, embraces about 4,480 acres. The largest tract forms a part of Gun Barrel slough, and another is the old marsh 2 miles northwest of Knoke. Few of the other areas include as much as 20 acres, and many are low spots within areas of Webster soils. All are in process of change to a shallow clayey soil, and all have shared in the benefits of artificial drainage so that the surface soil in most places is as dry as that of the Wabash and Webster soils. The depth of these peaty deposits varies greatly within the individual areas, but 10 feet or slightly more seems to be about the maximum depth. An average depth of 3 or 4 feet obtains in a very large proportion of the small areas and on the margins of the larger ones. In most places the underlying material is clay or mixed clay and sand, but in few places is it pure sand. In numerous places it was found to be soft impure

marl, changing with slight increase of depth to clay. In all places the basal clay is calcareous, and very frequently surface patches are strewn with small snail shells. In such places the soil itself is very limy.

With very few exceptions, the surface layer of these deposits is now very dark brown finely divided muck, in which the original coarse brown fiber has been almost entirely changed to this finer and more thoroughly oxidized condition. Although the material is rather loose it is seldom so fluffy, or light, as to yield easily to the wind, or to prevent the rise of capillary moisture well up to the immediate surface. If a little silt or clay has become mixed with the muck, as often occurs in small patches, the tillage properties are improved, but even in comparatively pure muck, cultivation with ordinary implements meets the requirements of tilled crops.

In most areas of muck, the light-textured surface layer changes at a depth of 15 or 20 inches to darker-colored soft plastic muck. There may be a little coarse fiber in the material but the properties are much like those of soft clay. Muck holds moisture well, and when mixed with the fibrous material the tillage properties of the latter are improved. The occurrence of this subsurface layer of plastic muck doubtless improves the cultural properties of the muck as a whole and tends to prevent the extreme degree of settling, or shrinking, that occurs in deep coarse fibrous deposits after being drained.

The water table in these areas is determined by the depth of adjacent ditches and the position of the tile drains. As a rule all the smaller areas are tillable and are regularly used for corn. Small grain is not often sown. The larger areas are more commonly used for pasture, and bluegrass thrives especially well, although the quality may not be so good as of that growing on mineral soils. White clover seems to prefer the marginal phases and mixed muck. A great variety of weeds, including hemp, sunflower, and smartweed, find these muck areas very congenial locations.

The character of the muck itself and the prevailing drainage conditions are very favorable for truck growing. Celery, cabbage, onions, potatoes, and numerous other vegetables thrive in gardens and could doubtless be produced on a commercial scale. The principal crop at present is corn, which yields from 25 to 75 bushels an acre, according to farmers' reports, the larger yields being obtained when applications of phosphates, potash fertilizers, or both are made. Low yields are obtained without fertilization. Fertilization is of especially great value for the truck crops.

Muck, shallow phase.—Numerous small areas of muck that originally consisted of a thin layer of peaty material over clay are mapped as muck, shallow phase. Under tillage the soil has become black and somewhat spongy, but it contains too much clay to be typical muck and yet is not quite like Webster silty clay loam. In many places the surface muck has received much silt and clay by wind drift and by erosion from adjoining higher land.

Practically all the land composed of these mixed phases of muck is in cultivation and where well drained is very productive. Corn, potatoes, all kinds of tame grasses, and the clovers thrive when fertilizers are used.

Alkali spots.—The term “alkali spots” is in common use with respect to areas within other soil types, in which crops are retarded in their growth and where corn fails to mature. In recently plowed fields these spots have a gray cast on the surface under ordinary moisture conditions, and if nearly dry the soil is loose and may be described as ashy rather than crumbly. At a depth ranging from 10 to 15 inches, or even less in some places, the subsoil is very light colored, owing to a high content of lime and other salts. As a rule this concentration does not extend below a depth of 40 inches, below which the usual clay, or mixed clay and sand, occurs.

These spots commonly occur along the rim of a local sag or at the margin of a Webster soil. In general, the low ridges rise only a foot or so above the adjoining low ground.

An excessive amount of calcium carbonate, or lime, commonly occurs in all the alkali spots. There are other salts, but the calcium carbonate and bicarbonate are the only ones occurring in such abundance as to cause injury to crops.⁶ All are soluble in water and are disappearing with improved drainage so they gradually have less effect on crops. Under certain conditions there may have been an increased accumulation of these salts at the surface immediately after artificial drainage was installed, but in general the reverse is true. In time all alkali spots will probably disappear. Few areas now involve more than 1 or 2 acres, many of them only a few square rods. Fertilization with potash has proved very profitable and is recommended for these alkali spots.⁷

SOILS AND THEIR INTERPRETATION

The soils of Calhoun County may be divided into two groups as follows: Soils which under precultural conditions were well drained and those that were very poorly drained. The poorly drained soils, which retain the higher content of organic residues, are very dark grayish brown or nearly black, and the well-drained soils, which are less rich in organic matter, are somewhat lighter colored, ranging from dark grayish brown to very dark grayish brown. In a few localities of very limited extent the prairies had been invaded by a forest growth, but its effect on the soil was slight. Many of the local basins were still occupied at the beginning of the cultural period by shallow ponds with much aquatic vegetation in and around them, but elsewhere the prairie grasses formed the soil cover. The coarse rank slough grasses almost monopolized the lowlands, whereas the less rank but more varied kinds occupied all the higher grounds.

The soils have developed under an annual rainfall of about 33 inches, a mean summer temperature of 71.5° F., and a winter mean of 20.1°. The depth of freezing under present conditions ranges from 2 to 3 feet.

The parent materials of all the soils are glacial deposits of late Wisconsin age. These consist of moderately heavy till composed chiefly of silt and clay, with a small proportion of sand. Along the streams, outwash sands and gravels form rather extensive bench

⁶ WARNER, H. W. MANAGEMENT OF ALKALI SOILS. Iowa Agr. Col. Ext. Bul. 124, 4 p., illus. 1924.

BANCROFT, R. L. THE “ALKALI” SOILS OF IOWA. Iowa Agr. Expt. Sta. Bul. 177, p. [186]–208, illus. 1918.

⁷ STEVENSON, W. H., BROWN, P. E., and BOATMAN, J. L. THE MANAGEMENT OF PEAT AND ALKALI SOILS IN IOWA. Iowa Agr. Expt. Sta. Bul. 266, p. [81]–100, illus. 1930.

lands. Stony materials form an extremely small part of the till, although scattered boulders occur on the surface. These large rocks include granites, quartzites, and greenstones, and fragments of shale and limestone are numerous below the weathered zone. Below the true soil layers the till is slightly oxidized, but not leached, to a depth ranging from 10 to 15 feet. There is more or less lime concentration within the partly oxidized zone, and in certain situations it is excessive between depths of 20 and 50 inches.

Drainage under precultural conditions, or more correctly speaking the prevailing moisture content of the upper part of the till, was a highly important factor in the development of the various soil types. Owing to the comparatively uniform character of the till, differences in the moisture content were determined chiefly by variations in local elevation and degree of slope. Therefore a close correlation exists between topography and soil type.

The various factors governing organic-matter accumulations in the surface layers resulted in a comparatively high content of this important constituent before the balance between gain and loss was reached. The gain, of course, was greatest in those soils occupying areas of slow drainage and least where the movement of soil water was more vigorous. In some places the underlying gravel deposits so facilitated escape of gravitational water, and consequently favored deep oxidation, as to prohibit much accumulation of organic matter in the surface layers, but such areas are of limited extent compared with those where conditions allowed a large accumulation. This organic residue is chiefly in the form of very finely divided carbonaceous matter intimately mixed with and coating the mineral soil grains. It largely determines the soil color and greatly influences the soil structure. The surface layers are crumbly and the clayey subsoil horizons are granular, the minute cleavage planes, or lines of fracture, being readily seen when a soil sample is broken. Thus the permeability of these clayey soils is greatly increased, and the moisture properties are vastly improved.

The presence of so much lime is a strong influencing factor in soil structure, as well as important in chemical relations. Below the humus-filled zones this mineral tends to loosen the material by its flocculating effect on the clay and colloids. To a depth of many feet the slightly oxidized till is distinctly friable, and in few places is it so compacted, or dense, as to offer much resistance to under-drainage.

Clarion loam represents the more advanced stages in soil development in this county. It has three distinct horizons. The first is the dark-colored crumbly humus-carrying zone, ranging from 20 to 30 inches in thickness; the second is a yellowish-brown layer, usually several feet in thickness, which is well oxidized and so well leached as to give no response to hydrochloric acid; and the third is light colored, usually yellowish gray, partly oxidized, and highly calcareous.

A representative profile of Clarion loam taken in a new road cut, 3 miles northwest of Lake City in the west half of sec. 2, T. 86 N., R. 34 W., is as follows:

From 0 to 8 inches, is dark-brown or very dark grayish-brown crumbly fine-textured loam, with rather small soft crumbs of silty material mixed with sand grains. The sample showed strong acidity.

From 8 to 18 inches, the material is slightly heavier and darker than the layer above, changing with increase in depth from soft crumbly to rather firm angular granules which are darker on the outside than on the inside. The soil mass is friable, easily permeable to water, and of medium acidity. A few quartz pebbles and coarse clean sand grains occur in this layer.

From 18 to 22 inches, is a transitional layer between the humus and mineral zones, in which some intrusions of dark material from the humus layer penetrate into the dull, or dingy, brown loam below. Most of the material in this layer breaks into coarse subangular particles ranging from one-eighth to one-fourth inch in diameter. Numerous worm casts and root veins penetrate this strongly acid layer.

From 22 to 42 inches, is yellowish-brown clay loam or heavy loam, containing much coarse material. The breakage is subangular and the material is of medium or strong acidity.

From 42 to 50 inches, is pale yellowish-gray silty pebbly material containing yellow and yellowish-brown stains. Some lime concentration, as specks and small flakes, occur in this layer.

Below a depth of 50 inches the light-colored till becomes highly calcareous and a little more compacted, and more stones and gravel are present than in the overlying layer. These include bits of shale and pieces of rounded or partly decomposed limestone.

The profile described has developed on gentle slopes of 4° to 8° inclination. On steep hillsides, the total thickness of the humus layer may not be more than 12 or 15 inches, and the yellowish-brown layer is barely developed. The light-colored calcareous till forms the subsoil. On slopes of less than 3° or 4° , Clarion loam is replaced by Webster loam in most places. In general, Webster loam occupies broad very gently rounded ridges.

An area of Webster loam on a ridge $3\frac{1}{2}$ miles east of Rockwell City on the north side of State Highway No. 20, in sec. 27, T. 88 N., R. 32 W., shows the following profile:

From 0 to 6 inches, soft, crumbly slightly acid very dark grayish-brown loam containing much organic matter.

From 6 to 26 inches, slightly darker colored, nearly black if wet, slightly acid silty clay loam in which the soft angular crumbs become angular granules in the middle and lower part of the layer. There is evidently much shrinkage and swelling in the soil material with changes in moisture content. The coarse sand grains are noticeably free from stains.

From 26 to 30 inches, a transitional zone, in which intrusions of humus penetrate into dull yellowish-brown silty clay loam which is alkaline and more or less crumbly.

From 32 to 38 inches, a porous friable silty material which is predominantly gray with very faint yellow stains. The soil in this layer is highly calcareous, with some lime concentration occurring as small flakes and soft specks.

From 38 to 50 inches, friable silty material containing a little more sand than the above layer and a few shale and limestone pebbles, changing with depth to mixed clay and calcareous gravel.

The ground water level is reached a little below 65 inches. The zone of mixed color between depths of 26 and 32 inches is the equivalent of the yellow-brown layer in Clarion loam.

A few hundred yards to the west on slightly more inclined surfaces Clarion loam is fairly well developed, and in the near-by flat spots Webster silty clay loam occurs.

Webster silty clay loam is essentially an accumulation of fine-textured materials without well-defined horizons. The outstanding physical characteristics are high organic-matter content and clayey texture. In many places the nearly black color, caused by an abundance of vegetal residues, may extend to a depth of 40 or 50 inches, but the average depth is somewhat less. To this depth fine clay and colloids form most of the mineral constituents. The organic material and lime impart a distinctly granular structure to what would otherwise be heavy plastic clay. In many places the material below the dark zone is dark-drab clay which becomes coarsely fissured on partly drying.

A typical profile of Webster silty clay loam at the margin of a small basinlike area, 1 mile south of Lohrville in the northeast quarter of sec. 22, T. 86 N., R. 32 W., shows the following characteristics:

The surface soil to a depth of 8 inches is very dark grayish-brown or nearly black silty clay loam. The material has a soft crumb structure and is slightly acid.

From 8 to 28 inches, very dark grayish-brown silty clay of granular structure occurs, in which the structure particles are small, angular, and comparable to rather coarse steel-cut coffee grains, closely packed together. The minute fissures between the particles are noticeable as the material becomes partly dry. When moist the structure is easily destroyed by pressure or manipulation, and then the high plasticity of the material becomes apparent. In the heaviest phases the clay is so highly plastic, or waxy, that the farmers call it "gumbo." In most places throughout the area of this soil the reaction becomes more alkaline with increase in depth in this horizon, and in some places the lower part becomes distinctly calcareous.

Below this rich humus horizon, between depths of 28 and 40 inches, a heavy silty calcareous clay occurs. On the larger areas where drainage is somewhat better, the color is gray, mottled with yellow and brown. In sloughs and well-defined depressions the color is dark bluish drab. On drying the material assumes a columnar structure, the intervening fissures of which are lined with dark colloidal material from the horizons above. In the usual moist condition the dark material appears as tongues penetrating this horizon.

Below a depth of 40 inches, the material changes to silty clay or silty clay loam and becomes more friable.

On the large areas the character of the material below a depth of 50 or 60 inches usually suggests modified till, in which the mixed gray and yellow colors and alkaline reaction are evidently caused by very imperfect oxidation and slight leaching. In many places lime has accumulated below a depth of 3 or 4 feet, as flakes and nodules. In some deeper exposures the abundant dark rust-brown stains suggest a concentration of manganese and iron.

On the very slightly elevated margins of the Webster soil areas there are in many places excessive accumulations of lime in the subsoil. Its presence is, in many places, revealed by the characteristic gray color of the surface soil of alkali spots; whereas, in other places,

there may be only a slightly higher degree of alkalinity in the surface soil than elsewhere.

This profile of Webster silty clay loam was tested for alkalinity. The results of this test and of a test of a profile of Webster loam are shown in Table 4. The pH determinations were made by the electrometric method, the hydrogen electrode being used.

TABLE 4.—*pH determinations of two Webster soils in Calhoun County, Iowa*

[3 cm ¹ soil, 1:2 soil water ratio]

Sample No.	Soil type	Depth	pH	Sample No.	Soil type	Depth	pH
		<i>Inches</i>				<i>Inches</i>	
3379103	Webster silty clay loam	0-8	5.77	3379113	Webster loam	0-6	5.92
3379104	do.	8-18	6.43	3379114	do.	6-26	6.10
3379105	do.	18-28	7.01	3379115	do.	26-32	7.33
3379106	do.	28-40	8.01	3379116	do.	32-38	7.96
3379107	do.	40-50	8.17	3379117	do.	38-50	7.98
3379108	do.	50-60	7.94	3379118	do.	50-65	8.10
3379109	do.	60-70	7.93				

¹ The abbreviation for cubic centimeter adopted by the Government Printing Office.

Since artificial drainage has become so efficient these concentrations of soluble salts at the margins of former ponds are in process of comparatively rapid reduction.

The profile of the Sioux soils indicates the depth to which leaching and oxidation have affected the beds of calcareous gravels and glacial rubble along the streams. The alteration has not commonly penetrated below a depth of 40 inches. The surface layers are distinctly acid. In many places, along their contact with the underlying gravel, there is much very dark reddish-brown material which may include manganese as well as iron oxide. This material forms part of the sticky clay which feebly cements the undecomposed pebbles and stones. Some shale and limestone occur, but these softer fragments have disappeared entirely from the upper layers.

The alluvium of the small streams changes from the Webster soils in the extreme upper structural depressions to alluvial soils in the erosional lower parts of the valleys. The Wabash soils consist of silts and clays, with some admixture of sand, but they are predominantly heavy. Those in the Racoon Valley have a wider range in texture and show slight development of a profile, owing to greater age and better local drainage. All fresh alluvial deposits are alkaline, but they soon develop some acidity in the surface layers, and in most places the subsoils do not react to hydrochloric acid.

SOIL CHANGES DURING THE CULTURAL PERIOD

The most evident soil changes that have occurred during the cultural period are those caused by erosion. On the steep phase of Clarion loam much of the originally thin surface loam has been removed, in many places exposing the light-colored subsoil. In most places the loss is not of serious consequence because the friable sub-surface material allows satisfactory tillage, and clovers and bluegrass thrive on account of the abundance of lime. Of greater consequence, although very generally overlooked, are the slow erosional changes in progress on the moderately rolling areas of Clarion loam. On the sides of prominent knolls and on all the stronger inclines elsewhere

there has been much removal of topsoil since the land was brought into tillage. This loss occurs chiefly as little mid-row washes where the ground is in use for corn. One instance was studied in some detail, and the following observations were made:

Early in July, 1929, the total rainfall during several successive days was 1.4 inches. None of this precipitation was torrential, much of it came rather slowly, and the cornfields were in excellent condition to absorb it. Careful observations on Clarion loam a few miles northeast of Rockwell City showed that the equivalent of one-tenth inch of soil had been washed off slopes having an inclination ranging from 2° to 5° . Much of this material was deposited along the foot of the slopes or on the adjoining Webster soils, but a large part was carried into the local streams.

Similar results of heavy rainfall were observed in many places during the summer. Most of the erosion occurred in cornfields, commonly as small transient gullies a few inches deep and wide. They were obliterated by the next cultivation of the corn or largely disappeared during dry weather. Some soil washing takes place after fall plowing and occasionally in the early spring in oat fields, but in the aggregate these losses seem slight compared with the more frequent losses in the cornfields.

The Webster soils are almost immune from erosional injury. Some washing may occur, however, if harrow or cultivator marks parallel the long inclines prevailing in some areas of Webster loam. The sediment that reaches the central part of the larger depressions within the Webster silty clay loam areas includes much very fine clay or soil colloids. Additional material of this kind does not especially improve the texture of these soils which already have a high content of clay.*

Broadly considered, the return of organic matter to the soil under present conditions is meager in amount and irregular in distribution. The oat stubble, if no clover has been sown, is in most places a thin cover, incapable of adding very much humus. Although an occasional heavy crop of clover or of weeds is plowed under, the usual practices in haymaking and grazing do not leave much of the plant growth above ground to be thus utilized. Since 90 per cent of the cornstalks remain in the fields, the contribution of organic matter from this source is doubtless greater than that direct from the oat stubble.

The small, semipermanent pastures maintained, so many of them near the farm buildings, usually receive a very large amount of manure compared with a similar acreage in the regularly tilled fields. The former practice of burning straw piles has been discontinued, but still much of this material is wasted.

Approximately 100,000 acres of land is plowed during the late summer and fall, and it remains bare of vegetation until covered by the next season's crop.

To what extent the precultural store of organic matter has been reduced by erosion, oxidation, and removal in crops can not be stated with any pretensions to accuracy. That it has suffered much diminution seems beyond doubt, especially where erosive losses are

* A laboratory examination of a composite sample of this gummy material collected in small depressions where water had stood after a heavy rain showed it to consist almost entirely of colloids, 9.3 per cent being organic matter.

apparent. Tillage operations and the deeper aeration induced by artificial drainage stimulate oxidation, but the total return of vegetal residues, as previously stated, seems very meager. Any marked reduction of organic matter in such a heavy soil as Webster silty clay loam seriously impairs the physical properties. Fortunately the Webster soils of this region still contain so much of this valuable constituent that their injury from this cause seems quite remote, but the Clarion soils present, in numerous places, evidences of diminished organic matter reserves. This is also true of the coarser-textured phases of the Sioux and Dickinson soils.

The suspended material in the streams is so dark colored and seems so easily transported as to indicate the inclusion of much material of organic origin. In the extensive improvements of the drainage ways little consideration has been given the possible retention of any of the sediments on the lowlands. Some deposition occurs on the Wabash silty clay loam areas, and in low places on Cass fine sandy loam, but elsewhere nearly all the material that reaches the larger ditches and the small creeks is discharged into the main streams. Their summer flow, even at low stages, is murky and at flood height becomes very dark colored.

Along nearly all old fence rows there is a ridge of wind-drifted soil, 3 or 4 feet wide and ranging from a few inches to 3 feet high. A large part of these accumulations date from the early years of tillage, but in March and April, 1930, much wind erosion occurred, and drifts formed to a depth of 1 to 2 feet along many roadsides and fences.

SUMMARY

Calhoun County, Iowa, includes an area of 568 square miles. About 95 per cent of the farm lands are tillable. The average size of farms is 164.7 acres. The chief crops are corn and oats. More than 50 per cent of the grain is sold direct from the farms, and the remainder is used in various ways on the farms.

All the principal soils are dark-colored prairie soils derived from glacial deposits rich in lime. An abundance of this mineral in the lower part of the subsoils and the high content of organic residue in the surface layers are outstanding characteristics of all the soils.

Clarion loam is the dominant upland soil, embracing most of the undulating and rolling lands. It is well adapted to general farming.

Webster silty clay loam includes most of the formerly poorly drained sloughs, depressions, and rather flat upland tracts, but practically all this land is now well drained. This soil is preeminently adapted to corn. Oats, clover, and a great variety of minor crops do well.

Webster loam occupies low ridges and slightly better drained locations than the silty clay loam.

The Sioux and some related soils occur on the bench lands along the streams. All are well drained by the underlying gravel beds.

The Wabash soils are dark-colored heavy bottom-land soils used largely for grazing, but they include some excellent cornland.

Most of the larger areas of muck, or peaty soils, are now so well drained as to be safely tillable. The largest tracts are used chiefly for pasture and the small spots are utilized in much the same way as the adjoining Webster soils.

[PUBLIC RESOLUTION—No. 9]

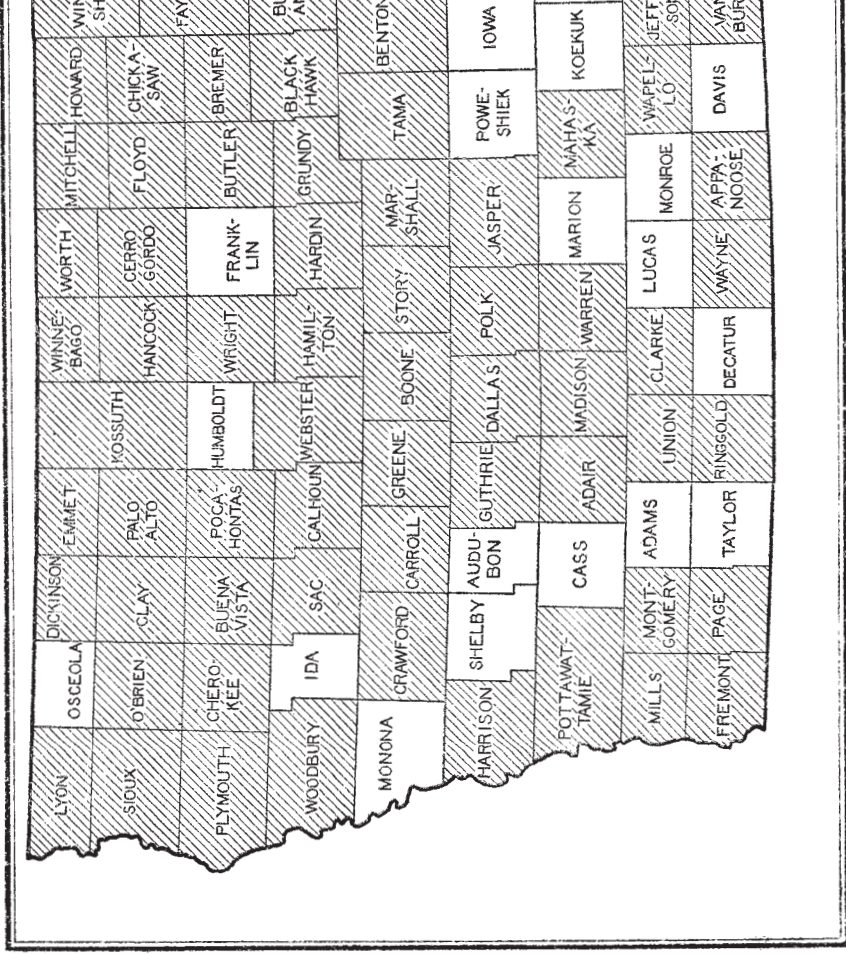
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Iowa, shown by shading

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